An AUV-Based Investigation of the Role of Nutrient Variability in the Predictive Modeling of Physical Processes in the Littoral Ocean

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LONG-TERM GOALS

Our long-term goal is to explore and test the potential effectiveness of low-level nutrient concentrations (nitrate, nitrite, and ammonia) as descriptors of geophysical fields and tracers of physical processes in oligotrophic coastal waters, with particular attention to adapting our laboratory sensor for these nutrients for use in an AUV. The nutrient data are to be incorporated into prognostic physical-biogeochemical models in a feedback mode.

OBJECTIVES

Objective 1: To conduct a well-designed test of the degree to which the behavior of ammonia (a nutrient in coastal waters) follows that of SF_6 (sulfur hexafluoride, a conservative tracer). This objective derives from last year's findings on the FSLE 4 cruise (Florida Shelf Lagrangian Experiment) that the West Florida shelf had surface boluses of high-ammonia water during periods of overturn.

Objective 2: To determine experimentally the appropriate length scale for modeling the behavior of a nutrient in coastal water. POM modeling commonly uses a 5-km scale, but LES modeling modified from Harcourt *et al.* (1998) suggests that a 50-m scale is more appropriate.

Objective 3: Modeling of coastal nutrient processes to exploit the use of nutrients as coastal tracers.

Objective 4: Improvements to our AUV nutrient sensor to measure nutrient distributions in detail.

APPROACH

Objective 1: Another West-Florida-shelf experiment in which the injection of the SF_6 tracer would be as close to an ammonia-maximum zone as possible. In previous cruises, the SF_6 was injected at a cur-

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rent-meter mooring, whether or not a nutrient-maximum zone was present. Key individuals were K. Fanning and R. Masserini of USF, who were responsible for the ammonia determinations, and R. Wanninkhof and K. Sullivan of AOML (NOAA), who were responsible for the injection and measurement of SF_6.

Objective 2: During our typical surveys at a speed of 3 kt., the Masserini-Fanning nutrient sensor collects and analyzes one sample of seawater every 200 seconds, while the ship travels ~300 meters. Two identical sensors sampling the same seawater stream could have their sampling cycles offset such that they should sample water parcels closer together than 300 meters – 10-second offset (estimated travel distance: 15 meters), 100-second offset (estimated travel distance: 150 meters), etc. Systematic differences between results within analytical error from the two sensors with different offsets should indicate the presence of nutrient variations on length scales of tens of meters. K. Fanning and R. Masserini of USF were responsible for this study.

Objective 3: To begin the biochemical ecosystem modeling required to define the usefulness of nutrients as tracers and lead to nowcast and forecast capability for coastal processes using nutrients. J. Walsh and his modeling group at USF, with data from K. Fanning and support from R. Weisberg's physical group (Weisberg *et al.*, 2001), is principally responsible.

Objective 4: Investigate ways to improve the range and detection limits for the nitrate, nitrite, and ammonia nutrient channels in the AUV version of our nutrient sensor to make them more compatible with those of the shipboard laboratory version of the sensor (Masserini and Fanning, 2000).

WORK COMPLETED

Objective 1: An experiment (FSLE 5) was conducted on a cruise to the Control Volume (west of Sarasota, Florida) in the latter half of April, 2001, aboard the *R/V F Walton Smith*. An ammonia-maximum region of coastal water was found on a pre-survey using our high-sensitivity nutrient sensor (Masserini and Fanning, 2000), SF_6 was injected at 10 meters, and both variables were followed by zigzagging surveys across their maximum zones for the rest of the cruise. Measurements on sub-samples of the flowing seawater stream from the ship's scientific seawater system provided the data.

Objective 2: A second Masserini-Fanning nutrient sensor was built and used alongside the original on the FSLE 5 cruise. Both sampled the same seawater stream, but with offsets in their sampling cycles ranging from 0 to 100 seconds.

Objective 3: The modeling began with a one-dimensional simulation analysis of nutrient cycling using data from earlier FSLE 1 and 2 cruises. Next came a study of what nutrients might be so rare in W. Florida coastal waters that they might be unavailable to phytoplankton and thus conservative (Heil *et al.*, 2001). Initial work, based on the finding that relevant ammonia length-scales were <u>kilometers</u> rather than meters, was conducted using POM rather than LES.

Objective 4: A new battery pack was identified that would increase the range of the AUV version, and the options of a new analog-to-digital converter for synchronization of light pulse and sampling plus optical and electronic isolation of components to reduce noise were also identified.

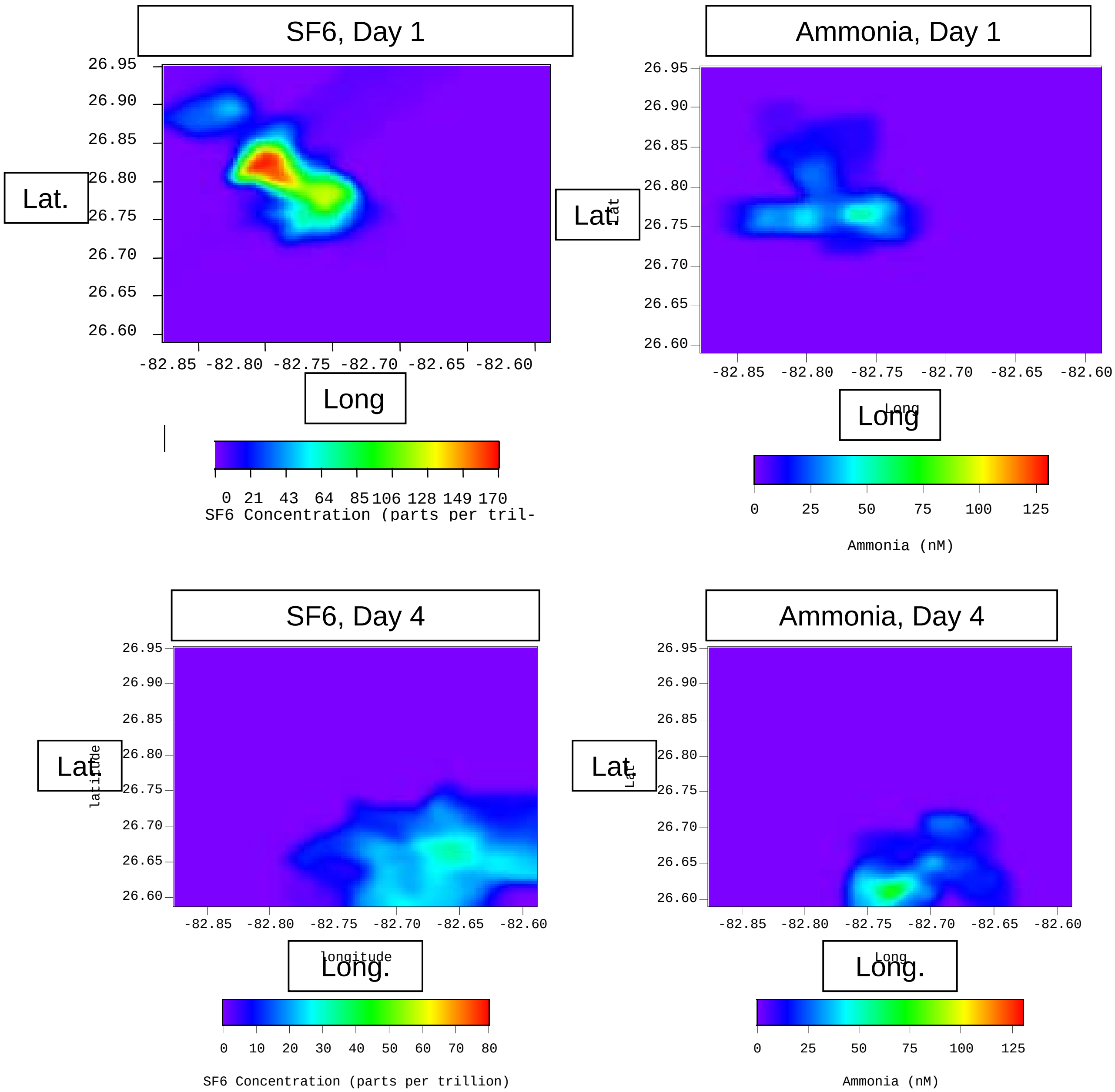

Figure 1: Time Course of Regions of High Ammonia and SF_6 on the W. Florida Shelf [Shows Color Contour Maps that Depict the Intermingling of West Florida Shelf Water Masses that are Enriched in Ammonia and Sulfur Hexafluoride and Fact that the Intermingling is Preserved as the Water Masses Drift to the Southwest for a Period of Four Days]

RESULTS

Objective 1: The overlapping regions of ammonia-enriched and SF_6-enriched coastal water followed each other quite well for over 4 days (Figure 1) demonstrating that ammonia could serve as a

conservative tracer. Based on the survey data, the experimental estimates of the time scale over which ammonia operates as a coastal water-mass tracer is 4-5 days.

Objective 2: Within analytical error, no variations were found between ammonia concentrations when sampling-cycle offsets were tried. Therefore, the most appropriate length scale for modeling coastal nutrient variations appears to be the size of the ammonia-maximum zones observed during the zigzagging surveys of FSLE 5: 1-2 km.

Objective 3: The early modeling of FSLE 1,2 was completed (Darrow, 2001; Darrow *et al.*, 2001). Nitrate was identified having too low an abundance to be biologically active on the W. FL shelf, and nitrogen-fixation was investigated as an alternative (Walsh and Steidinger, 2001; Lenes *et al*., 2001). Initial coupled biochemical models, using POM, to describe FSLE nutrient processes are now available (Walsh *et al.*, 2001a, b, c).

Objective 4: None yet.

IMPACT/APPLICATIONS

Nutrient concentration distributions obtained by both the laboratory version and the AUV-version of our nutrient sensor package can reveal differences in surface water types that will be useful for applying a hydrostatic models to compute flows within the POM grid cells. This will have applications to SF_6 studies, to prediction of red-tide distributions, and to estimates of tempo-spatial variance of IOP.

TRANSITIONS

Once the models replicate the observations of nutrient features interacting with physico-chemical processes on the West Florida shelf, we would anticipate applying them to other ongoing ONR field studies: COBOP at Lee Stocking Island in the Bahamas and LEO-16 on the New Jersey shelf.

RELATED PROJECTS

J. Walsh (N000149910212) is developing a model of plankton succession effecting bio-optical signals on the West Florida shelf. Forty-years of shelf nutrient, plankton, and physical data will be used along with our data to validate the model, based on existing circulation and nutrient-cycling models.

R. Weisberg of USF (N000149810158) is applying a primitive equation model at 5-km resolution to observed West-Florida-shelf current fields. It is an adaptation of the POM with topography-following vertical sigma coordinates and horizontal orthogonal curvilinear coordinates. Far-field shelf-break forcing is also being examined. It will provide boundary values for the POM-based modeling of nutrient/SF_6 data, and the resulting nowcasts and forecasts can be calibrated by our measured distributions.

P. Bissett of FERI (N000149810844) is applying Ecological Simulation 2.0 [EcoSim 2.0] to the West Florida shelf to model daily changes in the spectral quality of the downwelling light field. Daily IOP outputs are also coupled with the Hydrolight 4.0 radiative transfer code to predict the upwelling light field at 10:00 am each day. POM, LES, EcoSim 2.0, and the microalgal succession submodel described above will form a 3-D, ecologically complex, bio-optical shelf model (requiring our nutrient data).

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